WED-ID 6: Quantum Hardware, Software & Solutions

Time: Wednesday 15:10–16:45 Location: ZHG006

WED-ID 6.1 Wed 15:10 ZHG006

Evaluating Useful Quantum Advantage in the Calculation of Molecular NMR Spectra — •Keith Fratus, Nicklas Enenkel, Peter Schmitteckert, Andisheh Khedri, Juha Leppäkangas, Michael Marthaler, and Jan Reiner — HQS Quantum Simulations GmbH, Karlsruhe, Germany

An important question facing potential industrial applications of quantum computing is that of use case evaluation in the context of possible quantum advantage, or in other words, the question of whether simulating certain problems using a quantum computer would be worthwhile, or whether it would be sufficient to use traditional classical computers. Key to answering such a question is the ability to estimate the accuracy and performance of competing classical approximation methods when exact classical solutions are not available. In this talk we report on our efforts to develop and understand the behaviour of various classical approximation methods which aim to solve a specific class of chemical simulation problems. In particular, we develop classical simulation methods designed to predict molecular NMR spectra, with the aim of being able to quantify the accuracy and computational requirements of performing these simulations, even for parameter regimes which we do not directly simulate. Using such methods, we work towards a framework for predicting in which parameter regimes, system sizes, and target accuracies one can expect the failure of classical methods for this class of systems, thus allowing for an understanding of when quantum computation would be advantageous.

5 min. break

WED-ID 6.2 Wed 15:35 ZHG006

Security evaluation and certification of QKD devices — •Marc Wehling — TÜV Informationstechnik GmbH

The threat posed by quantum computers requires a new approach to cryptographic security. Although post-quantum cryptography (PQC) offers short- and medium-term security, its underlying mathematical structure could be susceptible to future attacks. Relying on fundamental physical laws, quantum key distribution (QKD) uses photons to encode secret data. Although the security proof provides security at the protocol level, the physical implementation can be targeted in numerous ways by an eavesdropper. Security at the implementation level remains to be evaluated. However, a certification scheme approved by a national certification body is a missing cornerstone. The QuNET+BlueCert initiative aims to fill this crucial gap by developing a blueprint for QKD security evaluation.

TÜV Informationstechnik GmbH (TÜVIT) is collaborating with partners from academia and industry to take a leading role in building a test laboratory for the security evaluation of various QKD components. The aim is to develop a certification scheme that will enable industry partners to protect their products against threats.

This talk covers threats to the implementation of QKD systems, as well as the current state of QKD certification, and provides an analysis of the elements missing on the way to a complete certification scheme.

5 min. break

Invited Talk WED-ID 6.3 Wed 16:00 ZHG006

Driven by Quantum, empowered by Quandela — •Thomas Volz — Quandela GmbH, Munich, Germany

Quandela is a world-leading full-stack photonic quantum computing provider. The company develops hardware, middleware, and software for a range of industrial applications, including energy, cybersecurity, and finance, showcasing the versatility of its unique technology.

The core of Quandela's innovation is its cutting-edge quantum-dot single-photon source technology that effectively eliminates barriers to the scalable manipulation of single-photon qubits. Featuring a modular, scalable, upgradeable, and energy efficient architecture, Quandela's mission is to deliver the first useful quantum computer to drive the quantum transformation to industry and society.

In this talk, I will give a brief intro into Quandela's technology, discuss the current state of development with a focus on real-world applications, and highlight some opportunities for joining Quandela's mission at its German subsidiary.

5 min. break

WED-ID 6.4 Wed 16:25 ZHG006

Provable Exponentially Enhanced QAOA on NISQ Hardware — •Chinonso Onah[1,2] and Kristel Michielsen[2,3] — [1]Volkswagen Group, Germany — [2]Department of Physics, RWTH Aachen, Germany — [3]Forschungszentrum Jülich, Germany

Industrial routing, scheduling and matching problems consume disproportionate compute budgets, yet their feasible solutions typically lie on a low-dimensional algebraic manifold (for example, subspaces with fixed Hamming-weight patterns). Vanilla QAOA must explore the full Hilbert space, diluting amplitude on invalid states and succumbing to barren plateaus. Consequently, we introduce Constraint-Enhanced QAOA (CE-QAOA), which starts and stays inside the exponentially smaller one-hot subspace of size n. A depth-optimal, ancilla-free encoder prepares a uniform superposition of single-excitation states per block, while a block-wise XY mixer preserves feasibility and is native to several hardware platforms. Circuit overhead is minimal: CE-QAOA adds at most the depth of a single XY block beyond vanilla QAOA.

Three exponential advantages compound from:

(i) Feasibility concentration. (ii) Exponential parameter-transfer amplification. (iii) Depth-robust exponential separation.

The framework extends to the traveling-salesman problem (TSP), the capacitated vehicle-routing problem (CVRP), graph matching, flow-shop scheduling, graph colouring, and more.